SCIENCE

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Use of Manpower

On December 29 the AAAS Council, meeting at Cleveland, Ohio, gave prolonged and careful consideration to the use of trained manpower in the present emergency. Aware of the fact that many official and unofficial, appointed and self-appointed, committees were working on the problem and making suggestions and recommendations, the Council was reluctant to befog the situation by making an independent set of proposals or by backing any of those already made; but it was the consensus that a group that represents every phase of science and technology should declare itself in general, but not uncertain, terms.

Two resolutions were passed unanimously by the 63 Council members present, but it was the feeling that the entire Council should express itself. On January 10, therefore, the resolutions were mailed to the Council, and 212 votes have been received. This is exactly 80 per cent of the total Council membership.

The text of the resolutions follows:

a) The American Association for the Advancement of Science affirms with all seriousness and conviction that it would be a national calamity not to make a maximum use in the present emergency of the scientific and technical skills possessed by our trained personnel; and that it would be equally calamitous not to assure an adequate continuing supply of such trained personnel.

b) To achieve these objectives of making a maximum use and assuring an adequate continuing supply of trained personnel, a system of Universal *National* Service, as distinct from Universal *Military* Service, should be instituted, to be administered by a carefully qualified civilian agency that will grant no deferments but will allocate all scientific and technical personnel to such national service as their individual training and skills permit, and national needs require.

The vote, though not unanimous, is decisive:

In favor of (*a*), 207 Opposed, 4
In favor of (*b*), 188 Opposed, 24

Comments were numerous, ranging from enthusiastic endorsement to qualification, query, or criticism. One member approved the first part of (*a*) but not the last part. Nearly 40 felt that part (*b*) should be "spelled out," specifically in regard to the qualifications and method of selecting the personnel in the civilian agency set up to allocate scientists, and in regard to application—whether to all scientists of all age groups or only to those within draft age limits.

Statements relative to the qualifications and method of selection of the personnel in the agency that will allocate scientists according to national need are not too difficult to formulate, but actual operation will, for its success, require a large agency that has access to accurate information regarding military and civilian requirements, on the one hand, and available scientific personnel, on the other. Decisions must be made by men with the perspective to assess the relative importance of competing demands for manpower in military, industrial, research, and educational areas. As many Council members stated, it is not a simple matter to put this kind of organization together.

As for age limits, they must be at least as flexible as those set in legislation covering military service. It should be a basic policy to apply no more regulations than the immediate situation requires. In an all-out war effort, however, the American Chemical Society's recommendation of "total mobilization of the nation's scientific and technical manpower between the ages of 18 and 65" does not appear too extreme, even in a democracy. Resolutions are meaningless unless translated into action, and these will be effectively publicized. It is further proposed to be ready, as an organization, to provide whatever assistance may be requested in the adoption and implementation of a wise program of manpower utilization.

Howard A. Meyerhoff
Administrative Secretary, AAAS

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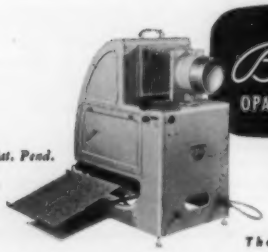

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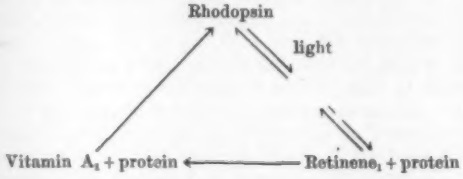
The Chemistry of Rod Vision

George Wald[1]

Biological Laboratories, Harvard University, Cambridge, Massachusetts

SOME YEARS AGO it was shown that rhodopsin, the red light-sensitive pigment of rod vision, takes part in a cycle of reactions of the following skeletal form (*1*):



Much of the physiology of rod vision reflects the composition of this cycle. The role of vitamin A_1 in rhodopsin synthesis is associated with the rise of night-blindness in vitamin A deficiency. The spectral sensitivity of rod vision has its source in the absorption spectrum of rhodopsin. In the light, rhodopsin bleaches to a lower steady-state concentration; the corresponding fall of visual sensitivity to a constant, depressed level is light adaptation. In the dark, rhodopsin is restored to its maximum concentration; the associated rise of visual sensitivity to a maximum is dark adaptation. Rhodopsin is synthesized in two ways—rapidly from $retinene_1$, and much more slowly from vitamin A_1; correspondingly rapid and slow modes of dark adaptation have been demonstrated in man and other animals (*2*).

Rhodopsin is found in the rods of land and marine vertebrates. In the rods of fresh-water vertebrates—lampreys, fresh-water fishes, and certain larval amphibia—it is replaced by the purple light-sensitive pigment, porphyropsin. This takes part in a cycle of precisely the same form as rhodopsin, but involving new carotenoids:

$$\text{Porphyropsin} \xrightleftharpoons{\text{light}} \text{Retinene}_2 + \text{protein} \longrightarrow$$
$$\text{Vitamin } A_2 + \text{protein} \longrightarrow \text{Porphyropsin}$$ (*3, 4*).

Recent work with these substances and processes has brought the chemistry of rod vision to a new level. I should like briefly to summarize this development.

[1] The recent work of our laboratory has been supported in part by the Medical Sciences Division of the Office of Naval Research. We wish to thank R. K. Bonnichsen for several gifts of crystalline alcohol dehydrogenase and for taking part in a preliminary experiment on the reduction of $retinene_2$. We wish also to thank Eric Ball and Octavia Cooper for their generous gift of a succinoxidase preparation from heart muscle.

Rhodopsin and Porphyropsin

Rhodopsin and porphyropsin are carotenoid-proteins—proteins bearing carotenoid prosthetic groups to which they owe their color and sensitivity to light. Each of these pigments possesses a single type of prosthetic group. The protein probably varies from one animal to another; it may be called *opsin*, and named for the animal of origin.

The absorption spectrum of rhodopsin consists of three bands (Fig. 1): a broad α-band, maximal near 500 mμ, which is principally responsible for the spectral sensitivity of rod vision; a small β-band in the near ultraviolet, at about 350 mμ; and a narrow γ-band at about 278 mμ. The α- and β-bands go with the carotenoid prosthetic group, the γ-band with opsin (*2*). The α-band is displaced in position in rhodopsins from various sources; it lies at about 498 mμ in cattle, rats, and dogfish; and at 502 mμ in the bullfrog (*1, 3, 5*). The first rhodopsin to be isolated from an invertebrate retina, that of the squid, displays a similar trio of absorption bands: an α-band at about 490 mμ, a β-band at about 360 mμ, and the opsin band in its usual position (*6*). In porphyropsin, the chromophore bands are shifted considerably toward the red, the α-band to about 522 mμ, and the β-band to about 370 mμ (Fig. 1).

In evaluating rhodopsin spectra, one can use the ratio of the extinctions at 400 and 500 mμ (400/500

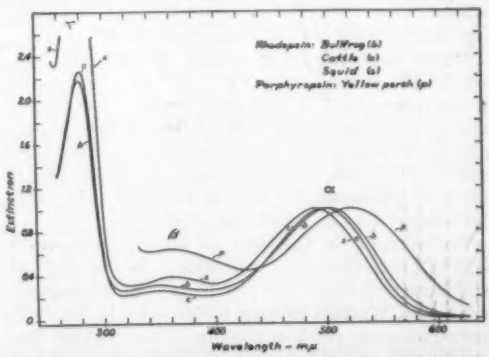


FIG. 1. Spectra of rhodopsins and porphyropsin, measured in 2 per cent aqueous digitonin. Preparations from the bullfrog (average of 3) by R. Hubbard and P. K. Brown; cattle and squid, by R. C. C. St. George; yellow perch by P. K. Brown.

ratio) as an index of "optical purity" (*1*). A similar 278/500 ratio provides a criterion of optical purity in the ultraviolet and indicates, also, the proportions of protein to chromophore in rhodopsin preparations. The spectra shown in Fig. 1 include the lowest such ratios so far recorded. They are almost equal in our best rhodopsin preparations from cattle and bullfrogs: $400/500 = 0.22 - 0.26$, and $278/500 = 2.2$. The former ratio is close to that of pure rhodopsin (*1*); the latter may be higher than that of the pure pigment.

Light absorbed by the prosthetic group of rhodopsin—i.e., in its α- and β-bands—bleaches the molecule and can be seen. Present data suggest that light absorbed in the protein band may not be available for bleaching. On bleaching rhodopsin in solution, the α- and β-bands are replaced by the spectrum of retinene$_1$, with a peak at about 385 mμ; the γ-band remains unchanged (*2*).

The spectra of rhodopsin and porphyropsin offer important clues to their chemical structure. The position of the α-band implies that, to form the chromophores of rhodopsin and porphyropsin, *two* molecules of the vitamins A or retinenes are united in conjugation. The β-band has the appearance of a cis-peak, such as is known to accompany linkages of *cis*-configuration in many carotenoids (*7*). It implies that the prosthetic groups of rhodopsin and porphyropsin contain such linkages (*2*).

The Bleaching of Rhodopsin

The bleaching of rhodopsin is initiated by a light reaction that forms unstable orange products (Lythgoe's "transient orange"); followed by ordinary chemical—i.e., "dark"—changes that end in the production of a yellow mixture of retinene$_1$ and opsin, in part loosely bound to each other (Lythgoe's "indicator yellow") (*1, 8*).

The light reaction was isolated for the first time by Broda and Goodeve, who irradiated rhodopsin at the temperature of dry ice, at which dark reactions scarcely occur (*9*). The processes involved in bleaching have recently been analyzed further (*10*).

When rhodopsin is irradiated exhaustively with white light at temperatures of −40° to −100° C, its α-absorption band is displaced about 5 mμ toward shorter wavelengths and rises (cattle) or falls (frog) slightly in height. The color changes very little, from red to orange-red, with little change in depth. This is the only photochemical step in the rhodopsin cycle. Its product may be called *lumi-rhodopsin*.

On warming in the dark to temperatures above −20° C, lumi-rhodopsin undergoes a further shift of spectrum toward shorter wavelengths, yielding *meta-rhodopsin*. Warmed to room temperature in the dark, meta-rhodopsin yields a mixture of regenerated rhodopsin and retinene$_1$ + opsin in about equal amounts (*5, 10*).

Kühne observed many years ago that dry rhodopsin does not appear to bleach, even in sunlight. In this state also, however, rhodopsin undergoes the light reaction, though with such small change in color as to have escaped notice. Rhodopsin prepared in dry gelatin films possesses a spectrum similar to that in solution. On exposure to light it yields lumi-rhodopsin; and in the dark this is transformed, even in the dry state, to meta-rhodopsin. Meta-rhodopsin is stable indefinitely, as long as it is kept dry; but on wetting in the dark it bleaches to yield a mixture of regenerated rhodopsin and retinene$_1$ + opsin in roughly equal amounts (*10*).

The spectrum of rhodopsin regenerated under these conditions lies at slightly shorter wavelengths than that of the pigment extracted from the retina. For this reason Collins and Morton have suggested that it be called "iso-rhodopsin" (*5*). Preliminary experiments in our laboratory indicate that "iso-rhodopsin" is a mixture of native and slightly altered rhodopsins. The altered forms not only have spectra displaced a few mμ toward the blue, but also are more susceptible to attack by such protein denaturants as methyl alcohol (*11*). All our experiments in which rhodopsin has been regenerated or synthesized *in solution* have yielded such products. It should be noted that the resynthesis of hemoglobin in solution from heme and globin raises similar problems (*12*).

The rhodopsin of the squid undergoes a pattern of changes on bleaching comparable with that of vertebrate rhodopsins. Bliss has described a pigment obtained from the squid retina ("cephalopsin"), which resembles rhodopsin in spectrum but is unaffected by light, though it decomposes in the dark. Bliss, however, made his preparations *in daylight* (*13*). What he has described is in fact meta-rhodopsin. Squid rhodopsin, like that of vertebrates, is relatively stable in the dark. On exposure to light it yields lumi-rhodopsin, and this decomposes in the dark by way of meta-rhodopsin to a mixture of regenerated rhodopsin and retinene$_1$ (*6*).

These experiments disclose a striking similarity between the bleaching of rhodopsin and the photographic process. In both cases light forms a "latent image" involving little visible change. Gross changes in color are the result of subsequent "dark" reactions—i.e., of "development." The parallel is particularly close in the case of gelatin films of rhodopsin, in which exposure to light yields a stable latent image composed of meta-rhodopsin, which can be developed at any later time simply by wetting (*14*). The rapidity with which the exposure of a retina to light leads to electrical responses in the optic nerve makes it probable that the excitation of the rods depends upon the light reaction itself and does not await the relatively slow bleaching of rhodopsin to retinene$_1$.

Reduction of the Retinenes to the Vitamins A

The demonstration by Morton and his co-workers that retinene is vitamin A aldehyde has given a singular impetus to recent work in visual biochemistry. Vitamin A_1 is the alcohol $C_{19}H_{27}CH_2OH$; retinene$_1$

is its primary oxidation product, $C_{19}H_{27}CHO$ (*15*). The structure of Vitamin A_2 is still uncertain; but it also is known to be an alcohol, and retinene$_2$ is its aldehyde (*16*). To prepare retinene one need only pour a solution of vitamin A_1 or A_2 in petroleum ether onto a short column of dry manganese dioxide; a solution of the corresponding retinene runs off as the filtrate (*17*).

In the outer segments of the rods, retinene$_1$ is reduced to vitamin A_1 by an enzyme system in which cozymase (*DPN*) acts as coenzyme (*18*):

$$\underset{\text{retinene}_1}{C_{20}H_{27}CHO} + DPN{-}H_2 \xrightarrow[\text{retinene reductase}]{} \underset{\text{vitamin A}_1}{C_{20}H_{27}CH_2OH} + DPN$$

This system can be assembled in solution from the following components: the coenzyme, *DPN*—H_2; as substrate, synthetic retinene$_1$, prepared by the oxidation of crystalline vitamin A_1 on manganese dioxide; and the apoenzyme, contained in a water extract of the homogenized retinas or the isolated rods of frogs or cattle (*19*).

In the retinas of fresh-water fishes, retinene$_2$ is reduced to vitamin A_2 by a similar enzyme system. The fish apoenzyme, however, like that of frogs or cattle, works equally well upon either retinene$_2$ or retinene$_1$. One has to consider, therefore, only a single apoenzyme, retinene reductase, which with one coenzyme, *DPN*—H_2 reduces either retinene$_1$ or retinene$_2$ to the corresponding vitamin A (*19*).

This enzyme system introduces a second vitamin into the chemistry of rod vision; for the key component of *DPN* is nicotinamide, the antipellagra factor of the vitamin B complex. It appears here, strangely enough, in the position of regenerating the vitamins A.

Retinene reductase may be even less specific than we have described. Bliss has stated that crude alcohol dehydrogenase preparations from mammalian liver catalyze the equilibrium between retinene$_1$ and vitamin A_1 (*20*). This observation has since been confirmed in our laboratory, with the crystalline alcohol dehydrogenase of Bonnichsen (*21*). Warren Yudkin has found also that an enzyme system from the retina oxidizes ethyl alcohol to acetaldehyde. It is possible, therefore, that retinene reductase is identical with alcohol dehydrogenase.

When the retinene reductase system has completed its action in the retina or in neutral solution, no measurable amount of retinene remains. It has been converted quantitatively to vitamin A. As will appear below, the system can be driven in the oxidative direction; but this demands special circumstances and the performance of external work.

The Synthesis of Rhodopsin from Retinene$_1$

Many years ago Kühne described two modes of synthesis of rhodopsin: a rapid "anagenesis" from yellow or orange products of bleaching, which occurs in the isolated retina and even in solution; and a much slower "neogenesis" from colorless precursors, which Kühne believed to occur only in the intact eye. These processes can now be identified with the synthesis of rhodopsin from retinene$_1$ and from vitamin A_1.

Recently Hecht *et al.* confirmed Kühne's observation that rhodopsin regenerates in solution after bleaching to retinene$_1$ and opsin. The largest regeneration recorded was about 15 per cent (*22*).

When rhodopsin is bleached in solution in the presence of added retinene$_1$, it regenerates strongly, with yields as high as 83 per cent. The concentration of retinene$_1$ that provides maximum regeneration is about 20 μg/ml (about 7×10^{-5} *M*). A mixture of rhodopsin and retinene$_1$, bleached repeatedly in the light, regenerates repeatedly in darkness (*23*).

Rhodopsin has also been synthesized in solution from its separate precursors. Opsin has been prepared from frog and cattle rods by a procedure that excludes most other molecules. Rod outer segments, isolated from completely bleached retinas, are tanned with alum to make most proteins insoluble; leached exhaustively with buffer solutions to remove all water-soluble material; and frozen-dried and extracted with petroleum ether, to remove fat-soluble substances, including carotenoids. From the solid residue of these treatments, clear, colorless opsin is extracted with the aid of the detergent digitonin. Opsin alone yields no light-sensitive material on incubation in the dark, but on mixing with synthetic retinene$_1$, it yields a lively synthesis of rhodopsin (*23*).

No other molecules seem to take part in this reaction. It is a spontaneous—i.e., an energy-yielding—process. It is the *bleaching* of rhodopsin—probably specifically the formation of lumi-rhodopsin—that requires energy, usually furnished by light.

Why does the regeneration of rhodopsin in solution require added retinene$_1$? The main reason for this is that the retinene$_1$, formed when rhodopsin bleaches, wanders away from its original sites of attachment to opsin, to couple with other groups on opsin and other molecules. One function of added retinene$_1$ is to saturate all such positions, and so make adequate retinene$_1$ available at the sites concerned with rhodopsin synthesis. Another function is simply to speed the synthesis of rhodopsin; for free opsin deteriorates relatively quickly in solution, and the faster rhodopsin is regenerated, the larger is the yield.

Frog opsin condenses with retinene$_2$ as effectively as with retinene$_1$ to yield a light-sensitive pigment. This possesses an absorption spectrum intermediate between those of rhodopsin and porphyropsin. Opsin from a porphyropsin retina (yellow perch), allowed to react with retinene$_1$ and retinene$_2$, yields much the same result: rhodopsin with retinene$_1$, the intermediate pigment with retinene$_2$ (*23*). The nature of the pigment obtained with retinene$_2$ is still uncertain. Perhaps it is "iso-porphyropsin."

The synthesis of rhodopsin from retinene$_1$ and opsin is blocked by hydroxylamine (0.10 *M*), which binds retinene$_1$ in the form of its oxime:

$$\underset{\text{retinene}_1}{C_{20}H_{27}HC{=}O} + \underset{\text{hydroxylamine}}{NH_2OH} \rightleftharpoons \underset{\text{retinene}_1\text{ oxime}}{C_{20}H_{27}HC{=}NOH} + \underset{\text{water}}{H_2O}$$

The synthesis of rhodopsin is blocked also by formaldehyde (2 per cent; 0.7 *M*) (*23*). We interpreted this effect originally as a competition between formaldehyde and retinene$_1$ for the amino groups of opsin with which both aldehydes readily couple; but a similar competition seems to involve sulfhydryl groups. We find that retinene$_1$—like formaldehyde (*24*)—reacts with the –SH groups of cysteine and glutathione, apparently yielding products of the type:

$$C_{19}H_{27}HC{=}O + RSH \rightleftharpoons C_{19}H_{27}CHOH{-}SR$$

(retinene$_1$ + sulfhydryl amino acid or peptide = retinene$_1$ thio complex).

Such a reaction probably plays some part in the synthesis of rhodopsin, for its regeneration after bleaching is blocked completely by the sulfhydryl poison, *p*-chloromercuribenzoate ($7 \times 10^{-5} M$). This inhibition is reversed by adding glutathione. It may be concluded that sulfhydryl groups of opsin play an essential role in rhodopsin synthesis (*25*).

We have stressed in this discussion the synthesis of photosensitive pigments from the retinenes. In reality, however, we had in these experiments synthesized rhodopsin from vitamin A_1, and a comparable light-sensitive pigment from vitamin A_2; for our retinenes were prepared from the corresponding vitamins A by oxidation on manganese dioxide. This was an unphysiological process; but its success led us to look for a physiological mechanism that might oxidize vitamin A to retinene efficiently in the retina.

The Oxidation of Vitamin A_1 to Retinene$_1$

In solution and in the isolated retina the equilibrium of the retinene reductase system lies far over toward the side of reduction. The same can be said of the closely comparable alcohol dehydrogenase systems of liver and yeast, in which the equilibrium in neutral solution lies far over toward the production of alcohol. To make the latter type of system produce appreciable quantities of acetaldehyde at neutral reactions, it is necessary to introduce an aldehyde-trapping reagent, which drives the system in the oxidative direction by binding aldehyde as fast as it is formed.

By the same means one can drive the retinene reductase system to oxidize vitamin A_1 to retinene$_1$ (*20, 26*). As retinene-trapping reagent we have introduced hydroxylamine. In the presence of this reagent, retinal homogenates have been observed to oxidize vitamin A_1 to retinene$_1$ with yields of about 50 per cent (*26*).

It is not commonly understood that such a trapping reaction plays an essentially *energetic* role. To drive a reaction away from its equilibrium position requires that work be done; and the essence of a trapping reaction is that it does this work. In the present instance, the energy needed to oxidize vitamin A_1 to retinene$_1$ is supplied by the exergonic condensation of retinene$_1$ with hydroxylamine.

For this reason it is important that the condensation of retinene$_1$ with opsin also is exergonic, and so can serve as a retinene-trapping reaction. In the rods, opsin may substitute physiologically for hydroxylamine and may drive a continuous oxidation of vitamin A_1 to retinene$_1$, by continuously removing retinene$_1$ to form rhodopsin. This constitutes a potential mechanism for the synthesis of rhodopsin from vitamin A_1 in the retina.

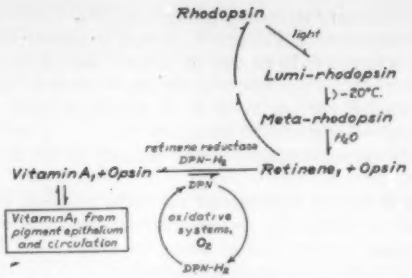


FIG. 2. Known components of the rhodopsin system. The intermediate steps in the bleaching of rhodopsin may not all be retraced when retinene$_1$ and opsin recombine to form rhodopsin. The bulk of the rhodopsin system lies within the outer segments of the retinal rods, but it is supplemented with vitamin A_1, respiratory factors, and oxygen itself from the pigment epithelium and the blood circulation.

The Synthesis of Rhodopsin from Vitamin A_1

The idea just expressed encounters an immediate difficulty. It has been believed since Kühne that the isolated retina, bleached to colorlessness, cannot regenerate rhodopsin. Yet it contains all the components considered above: vitamin A_1, retinene reductase, cozymase, and opsin. This inadequacy of the isolated retina caused Kühne to conclude that the synthesis of rhodopsin from colorless precursors requires new material, obtained in part from the pigment epithelium.

We have found that isolated frog retinas and retinal homogenates do in fact regenerate rhodopsin from vitamin A_1, in amounts about 10 per cent as large as are formed during dark adaptation *in vivo*. If a retinal homogenate is supplemented with cozymase, the yield of rhodopsin is approximately doubled. The addition to a retinal homogenate of a homogenate of the pigment layers of the eye—pigment epithelium and choroid—also doubles the yield. The pigment layers add to the system something other than cozymase, for the effects of these two supplements are additive, and when both are added together to a retinal homogenate, the yield rises to about 40 per cent (*26*).

We have observed also the synthesis of rhodopsin from vitamin A_1 in clear digitonin extracts of bleached retinas, supplemented with vitamin A_1 and cozymase. The maximum yield obtained in such preparations was about 25 per cent (*26, 27*).

The apparent role of cozymase in these syntheses is to supply coenzyme to the retinene reductase system. It suggests that rhodopsin synthesis may indeed proceed via the coupled oxidation of vitamin A_1 to retinene$_1$. We have therefore inquired systematically into other conditions that are expected to promote this

oxidation: a high concentration of vitamin A_1, and the presence of oxidative mechanisms that might keep cozymase in the oxidized state.

The addition of vitamin A_1 in oil to retinal homogenates increases their yield of rhodopsin by about 65 per cent. The addition of a so-called succinoxidase system of heart muscle (*28*) also increases the yield about 35–50 per cent. It is true, therefore, that those factors which promote the oxidation of vitamin A_1 to retinene$_1$ by the retinene reductase system also aid in the synthesis of rhodopsin (*27*).[2]

What do the pigment layers contribute to this synthesis? We can now offer a partial answer to this question, for in our homogenates the pigment tissue can be demonstrated to supply the retina with vitamin A_1. Retinal homogenates, freed from vitamin A_1 by extraction with petroleum ether, are unable to form rhodopsin. On addition of pigment layer homogenate they synthesize rhodopsin in high yield. The only vitamin A_1 available to them for this process is supplied by the pigment epithelium (*27*).

Finally, we have constructed a model system from the following components in solution: purified opsin, prepared from cattle retinas; the crystalline alcohol dehydrogenase of Bonnichsen, prepared from horse liver; vitamin A_1; and cozymase. On incubation in the dark, this mixture generates rhodopsin (*27*).

There is little doubt, therefore, that in the retina rhodopsin is synthesized at least in part by the oxidation of vitamin A_1 to retinene$_1$ by retinene reductase, coupled with the condensation of retinene$_1$ with opsin to form rhodopsin. In this system, the endergonic oxidation of vitamin A_1 to retinene$_1$ is the limiting process. It can be accomplished only to a small degree by the isolated retina; but with adequate supplementation, retinal homogenates and extracts, and our model enzyme system, perform this process efficiently.

There is as yet no evidence for an alternative mechanism of rhodopsin synthesis. Such an alternative pathway may exist; but it now appears probable that what has been interpreted since Kühne as a special mechanism for the synthesis of rhodopsin from vitamin A_1 consists in reality of the special conditions which drive the oxidation of vitamin A_1 to retinene$_1$.

The present status of the rhodopsin system, in terms of its known reactions, is summarized in Fig. 2. By all indications, a similar diagram will eventually describe also the porphyropsin system.

[2] Some of these factors must overlap in their effects, for the largest yield of rhodopsin we have obtained *in vitro*, using supplements in combination, is about 60 per cent.

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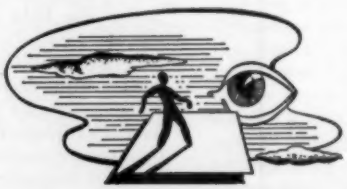

Technical Papers

The Informational Capacity of the Human Eye

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Critical examination of existing monocular visual acuity data has allowed an estimate of the informational capacity of a human eye to be made in this paper. The problem, analogous to that of the ear (*1*), is simpler in that visual acuity is ordinarily measured in a way which allows a calculation of total numbers of yes-no decisions, i.e., the standard informational units of "bits" (binary digits) to be made directly.

The maximum acuity of the eye, measured as the inverse of the minimum angular distance necessary to resolve two objects under conditions of good illumination and central fixation is 60/degree (1′ of arc is the acuity angle) for a person with "normal," or Snellen 20/20, vision. Consensus of data (*2–5*) indicates a variable, but higher, acuity figure for many eyes at high illuminations. We have somewhat arbitrarily taken 100/degree as the maximum acuity.

If the visual pattern be regarded as a fine mosaic of "acuity squares," which are either black or white, of an area corresponding to the square of the acuity angle, lasting for a time of the order of the fusion period, the informational capacity can be calculated. The tacit assumption is that the acuity square can be recognized as either present or absent, in a complex retinal pattern, thus furnishing one yes-no decision, or bit of information. With the Landolt ring method of measuring acuity, this is a defensible standpoint, since the discrimination of the presence or absence of the square that size in the pattern is the major task of the eye during the test.

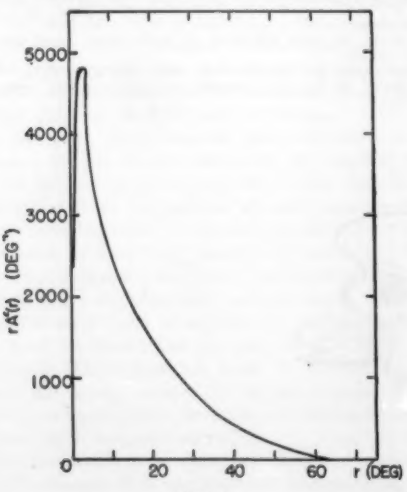

FIG. 1.

This model, which is a discrete "cell" representation of changes on the retina with time and space, will require a number of bits/sec for specification equalling the total number of such squares/mosaic multiplied by the frequency of appearance of new mosaics. This paper utilizes critical estimates of the best available experimental data bearing on these two quantities.

The classical study of the peripheral dependence of visual acuity is that of Wertheim (*6*). A number of more recent, and better, studies have been made on acuity in the macular region (*7–10*). A critical composite of the recent data up to 4½° peripheral, and of the Wertheim data beyond this, is replotted in Fig. 1, as the function $r\,A^2\,(r)$, where r is the peripheral angle of vision (degrees), and $A\,(r)$ the acuity, in inverse degrees. Assuming $A\,(r)$ to remain azimuthally constant, the total number of acuity squares is seen to be $\int_0^\infty \pi r\,A^2\,(r)\,dr$, or π times the area under the curve of Fig. 1.

Numerical integration of this curve, and multiplication by π gives a figure of 240,000 acuity squares/mosaic.

To find the maximum number of such mosaics perceptible in a second, two data are used: (*a*) the observation that the eye will integrate signals at high illumination and central fixation over a period of about 0.03 sec (*11*), and (*b*) the measurement that the decrease of the fusion frequency at a peripheral angle of 10° is about 1.8-fold (*12*). This is the center of density of the acuity squares plotted in Fig. 1. These data give $1/(.03\times1.8)=18$ mosaics/sec, a number less than half the maximum fusion frequency, but sufficient to give good fusion of successive mosaics. Multiplying this figure by 240,000, we arrive at 4.3×10^6 as the maximum number of bits/sec of information transmissible through the human eye, considered as an informational channel.

This figure is valid under conditions of high illumination. For light of lower intensities, both the acuity and the fusion frequency decrease substantially. The only data available on over-all change in retinal acuity with decreasing illumination are those of Mandlebaum and Sloan (*8*). Fig. 2 is a plot of these data after integrating over the whole retina to convert to informational units, and correcting for decrease in fusion frequency. It resembles an ordinary acuity-illumination curve, but the usual break between rod and cone vision levels is smoothed out by the spatial integration used.

The increase in informational capacity from color perception has been ignored. It would certainly not

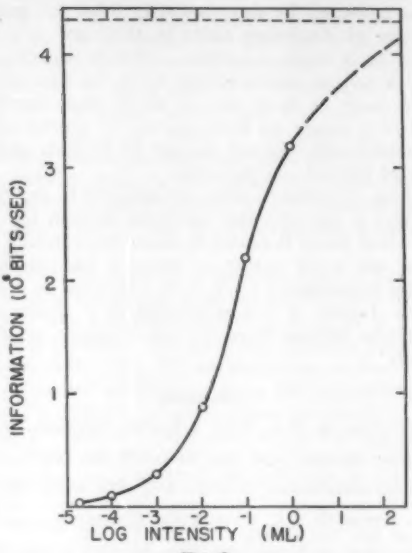

FIG. 2.

triple the capacity, and the increase is probably small compared to uncertainties in the data and methods of calculation.

Comparison with similar figures for the ear leads to interesting results. For "random" sound—i.e., sound evenly distributed in frequency and intensity throughout the hearing region—a capacity of 8,000 bits/sec has been calculated for the ear (*1*). Intense sounds will give a 10,000 bit/sec capacity, a result more nearly comparing to the high-illumination calculations of the present paper. A 430-fold difference, informationally speaking, is seen to distinguish the maximal capacities of the two receptors.

A factor of about 30 in the relative capacities of eye and ear can be accounted for by the ratio of nerve fibers leading from these organs (*13, 14*), but a further difference is evident in the efficiency with which an individual nerve fiber transmits information. The order of 5 bits/sec, av, can be produced by the 900,000 fibers of the optic nerve, compared with a maximum of about 0.33 bits/sec from each of the 30,000 fibers of the auditory nerve. This is clearly due to the greater independence with which the optic nerve signals are produced, in contrast to the prevalence of cooperative signals in the auditory bundles. The phenomenon of masking is less apparent in signals from the eye, which may be said to encode its observations more efficiently.

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The Percutaneous Absorption of Water

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The question whether externally applied water can penetrate the intact mammalian skin has long been debated. The gravimetric technique was employed in early experiments in which the subject was weighed before and after immersion. Working with human subjects, Stejskal (*1*) reported a retention of 200–300 g of water from the bath, Burr (*2*) observed a 5–7 g gain in body weight, and Pitta (*3*) reported a gain of 11.4–96.0 g, depending on the temperature of the bath. Schwenkenbecher (*4*) has criticized the results of Stejskal and others on the ground that the technique is not precise. More recently Whitehouse *et al.* (*5*) reported the results of carefully conducted experiments and concluded that water can pass inward through the human skin under certain conditions. These experiments have also been the subject of severe criticism, because the gravimetric technique was used, and Rothman (*6*) has claimed that water cannot pass through the mammalian epidermis.

Even if it can be proved that skin does take up water, none of the work so far reported offers final proof that this water enters the systemic circulation. Several investigators (*2, 7, 8*) have indicated that the answer to this question is important, and Burr (*2*) suggested that percutaneous absorption of even small amounts of water may exert a great influence on the water and mineral content of body fluids, on the circulation of nutrients, and especially on the exchange of substances between blood and tissues.

In the present study a tracer technique was used. Cylindrical wire containers with adjustable metal collars kept the animals in position and prevented the ingestion of D_2O. Young male rats weighing approximately 120 g were immersed for 6–7 hr in a mixture of 6 parts of H_2O and 4 parts of D_2O, maintained at a constant temperature of 35° C. The animals were then removed from the bath, drained, anesthetized lightly with ether, removed from cages, and quickly dissected to expose the heart. Blood samples were drawn from the pumping heart, using a syringe. Water was distilled from the blood samples,

[1] The authors are grateful for a grant from the Procter & Gamble Company in partial support of this investigation.

TABLE 1

Rat No.	Rat shaved	Wt of rat (g)	Length of immersion (hr)	D_2O in immersion liquid (mole %)	D_2O in blood (mole %)
1	yes	119	7	41.0	3.27
2	"	128	6½	40.6	0.72
3	no	118	6½	42.2	1.37
4	"	110	6½	40.9	1.42
5	"	118	6	40.1	0.70
6	yes	140	6	39.1	.80
7 (control)	no	152	6	0.0	.0
8 (")	"	170	5½	.0	.0
9 (")	"	198	6	.0	.0
10 (")	"	200	6	0.0	0.0

purified, and analyzed for deuterium content by the method of Keston, Rittenberg, and Schoenheimer (*9*). The results of these analyses are presented in Table 1.

It is evident from Table 1 that the deuterium oxide content of the blood of the test animals varied considerably even though they had been immersed in deuterium water for approximately the same period of time. The average deuterium oxide content of the blood of this group of animals was 1.38 mole %. The high deuterium oxide content of the blood of the test animals as compared with the controls is proof that the heavy water in which they were immersed penetrated through the skin and entered the systemic circulation.

It may be suggested that this D_2O entered the body in inspired air. This is not possible, for, if it is assumed that the air was 100% saturated with 40% deuterium oxide, and that all the deuterium oxide was retained by the lungs, rat No. 5 would have had to inhale about 840 liters air/min to reach a blood value of 0.70 mole % after 6 hr.

In three instances the fur from the trunk portion of the animal was removed by clipping and by an application of adhesive tape, two days before the immersion. This did not appear to influence the penetration of deuterium oxide, possibly because the hair did not interfere with the wetting of the skin of the immersed animal.

In a subsequent series of experiments (Table 2) rats were held so that only their tails were immersed in about 40% deuterium oxide. After the tails had been immersed for approximately 6 hr, the average content of deuterium oxide in the blood was 0.12 mole %. A rough calculation indicates that the area of the tail is approximately 1/10 the area of the whole body of these rats. It would seem, therefore, that on a square cm basis the rate of penetration of deuterium oxide through the skin of the body and the skin of the tail was the same.

TABLE 2

Rat No.	Tail length	Length of immersion	D_2O in blood (mole %)
11	—	6½ hr	0.08
13	7 in.	6 "	.18
13	6 13/16 "	6 " 10 min	.23
14	6 10/16 "	6 " 10 "	.08
15	6 8/16 "	5 " 45 "	.07
16	6 8/16 "	5 " 45 "	0.09

These experiments were not designed to determine whether a loss of water molecules through the skin had taken place. It cannot be stated dogmatically that there was a net uptake of water, a fact which all earlier investigators (*1, 2, 3, 5*) attempted to demonstrate. Indeed, it is possible that their results were indefinite because there was an exchange of water molecules.

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Social Fitness versus Reproductive Fitness

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It has been an axiom in genetics that if a mutant gene is to spread in a large population it must confer a selective advantage upon the individuals in which it occurs. In the broadest sense this axiom is true for man as well as for other organisms. One reason for a more detailed consideration of specific genes in man is that a deleterious gene that lowers social fitness could increase reproductive fitness.

Social fitness could be measured by an individual's contributions to civilization in the form of cultural heredity. Such gifts to the present and future might be either material or intellectual or both.

Reproductive fitness could be measured by an individual's contribution of his genes to future generations as demonstrated by the number of his descendants. The exact wording of these definitions may be ignored, but the ideas expressed are useful for an understanding of this paper. The "fitness" of a genotype has been defined in detail by Fisher (*1*), by Haldane (*2*), and by Penrose (*3*), and they use the term "fitness" as a measure of reproductive effectiveness. Consequently, the idea of reproductive fitness is well established in human genetics.

The presence of an inverse correlation between the

cultural and the biological contributions of the individuals of any particular generation has been demonstrated repeatedly. It is still impossible, however, to evaluate the effects of this inverse correlation upon the genetics of future generations. The difficulties involved in the genetic study of an important social character, such as intelligence, are many. It is possible, however, to study the relationship between social fitness and reproductive fitness when a clear-cut dominant gene such as that for Huntington's chorea is present.

An extensive study of Minnesota families containing the simple dominant gene for Huntington's chorea has just been completed by one of us (J. D. P.) and will be published in full elsewhere. We came upon the problem in this way. The state director of social welfare requested an opinion as to the advisability of placing a child for adoption whose grandmother had a "nervous disease." The family denied that any other relative had this same disease. The authors soon discovered that there were many close relatives with the disease, which was diagnosed as Huntington's chorea. The disease has been named by the members of the family after the original Minnesotan from whom they descended. It is feared and dreaded by all, and justly so, as it causes social damage to every member of the family, as well as the death of those who inherit the gene.

The original migrant to Minnesota was a man we shall call A. He was born in 1831 and came here accompanied by his brother, B, born in 1834. They adopted a new family name with the hope that their past would be left behind them. Unfortunately this was not to be the case. Their past was to be their future as well. The rich new lands of Minnesota offered great opportunities for those free from genetic defects—but A was not free. The two brothers each produced 10 children. As time passed, A and some of his descendants developed Huntington's chorea. The brother, B, and his descendants escaped the gene for the disease. They attempt to dissociate themselves from the affected branch of the family and have been partly successful in escaping the social consequences of the gene possessed by their relatives.

The effect of the gene for Huntington's chorea upon social and reproductive fitness is easily seen in the branches of this family. The onset of chorea lowers the economic standing of the family because the affected parent loses employability shortly after the onset of the disorder. Furthermore, a second member of the family must often give up employment in order to care for the choreic member. This loss tends to lower the social class of the family, and the stigma of the parent's disease will force the children to accept mates from a lower social stratum (if any) than their own. With the gradual drop in social class the reproductive rate may be expected to rise, and the deleterious gene must increase also in relation to its normal allele in higher social strata.

The continuing effect, as the generations pass, of the Huntington's chorea gene in depressing social fitness and stimulating reproductive fitness is easy to ascertain at the local scene and can be expressed quantitatively by tabulating the number of descendants of the two brothers.

There have been 787 descendants of A, of whom 716 are living. It will be recalled that B also produced 10 children, but he has only 186 descendants, of whom 167 are living. There are thus slightly fewer than 1/4 as many descendants of B as of the affected brother, A. It should be emphasized that great diligence has been exercised in checking the descendants of both brothers in order to be certain that every child born in each generation has been carefully accounted for regarding his own reproduction, both legitimate and illegitimate.

Although the descendants of A are 4 times as numerous as those of B, it should be evident that B has many more descendants than would be expected from a man of average social standing. An example of the opposite extreme, which appeared in the Minneapolis *Tribune*, comes from the genealogy of a former prominent citizen, Governor John S. Pillsbury, who was born in 1827 and came to Minnesota at the same time as the two brothers. There have been 19 descendants of the governor, of whom 15 are living. Of the 898 *living descendants* of these three contemporaries, 80% are from the choreic A, 18% from B, and 2% from the governor. This is a quantitatively established example of differential fecundity for the gene pair concerned with Huntington's chorea.

It would be useful to determine the rate of increase that might be expected among the descendants of an "average" man born in 1830. Unfortunately, such calculations would be difficult to make because of the effect of subsequent immigrants and their descendants upon the rate of increase. The increase in life expectancy would also confuse the issue. Consequently, we have had to content ourselves with comparing the number of descendants of the 3 men with the number just needed in a hypothetical stationary population to replace the original man and his wife and the unrelated persons who marry his descendants. In simplest terms there would have to be 2 children, 4 grandchildren, 8 great-grandchildren and 16 great-great-grandchildren, a total of 30 required descendants. Actually, the average man will have produced many more than this, inasmuch as the population has not been stationary. But the average man of 1830 failed dismally to equal the performance of A, who has 787 descendants credited to him. This is 26 times the stationary replacement figure. Even B, with 186 descendants, gives a value of 6 times the replacement figure. On the other hand, the 19 descendants of Governor Pillsbury account for only 6/10 the number required for replacement.

There is an interesting additional effect of the gene for Huntington's chorea, an effect acting directly upon the fecundity of the affected person. The effect apparently occurs well before the onset of the disease. The

number of children ever born from affected persons was compared with the number ever born to their unaffected sibs, for all Huntington's chorea pedigrees worked out by us. The average number of children from affected individuals was 6.07 ± 0.9, and from unaffected sibs 3.33 ± 0.5. The difference between these means is 2.74 ± 1.03 and is statistically significant. A similar difference was also present in the entire material from the literature. It was present, consistently, when the sexes of the affected and unaffected persons were treated separately, when surviving children were compared with those ever born, both for the Dight Institute material and the literature. Eight different comparisons all gave excesses for the affected. (Our explanation for these differences is not well enough established to include here.)

Let us return to the effect of social class upon the spread of a medically deleterious, but reproductively advantageous, gene such as Huntington's chorea. Brother A and 18 of his descendants have already had the disease in extreme stages, usually accompanied by commitment to a state institution. A number of others are in early and moderate stages of the disease. It is a simple matter to calculate the number of expected descendants of A, now living, who will eventually develop the disease, which has a late onset in this family. In addition to the 19 obvious cases, we expect 101 additional cases if those persons with the gene reach their age of onset. This would make a total of 120 cases, a remarkable rate of increase for the gene introduced by this one man. These patients will cause great trouble and expense before their deaths, which are usually the result of exhaustion. It is practically impossible to care for them at home during the last few years of the disease; consequently, the state assumes the burden.

Patterson, Bagchi, and Test (*4*) have indicated that it is possible to detect a potential case of Huntington's chorea before the reproductive age, by means of the electroencephalograph. The descendants of A offer excellent material for testing the usefulness of the electroencephalogram in detecting Huntington's chorea early enough so that a voluntary eugenics program could be undertaken. Even partial success would be of value, although the psychological approach to the potential victims of the disease would have to be skillful.

An extensive program of testing the descendants of A with the electroencephalograph has been begun. They are also submitting most graciously to the Wechsler-Bellevue intelligence test and to the Rorschach and the Minnesota Multiphasic Personality tests. It is hoped that these latter tests may give some hint as to personality differences that would account for the greater fecundity of persons who will later acquire the disease.

This study demonstrates the way in which the dominant gene for Huntington's chorea has spread, not only because it increases the fecundity of the affected person compared with unaffected sibs, but also because the social stigmata connected with the disease confine the close relatives to the lower social strata. Persons with little education (and usually lower social fitness) have higher than average reproductive fitness, as shown by the U. S. census. This situation favors the spread of the gene for Huntington's chorea.

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A Rich Source of γ-Carotene[1]

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In 1940, Emerson and Fox (*1*) reported the occurrence of a high concentration of γ-carotene in the male gametangia of the Phycomycete water-mold *Allomyces*. These workers concluded that the synthesis and storage of carotenoids are usually associated with the processes involved in the metabolism of reproduction. Later, Smits and Peterson (*2*) showed that the orange color of the expanded telial galls of the rust fungus (*Gymnosporangium juniperi-virginianae* Lk.) was due in part to carotenoids, of which 36% was the rare γ-isomer.

The heteroecious rust fungus (*Gymnosporangium juniperi-virginianae* Lk.) produces telial galls on the common juniper (*Juniperis virginiana* L.) and pycnia and aecia on the leaves, young twigs, and fruit of apple species and related genera. The telial spores produced by the telial galls in the spring infect the apple and produce two types of injury on the leaves, the epiphyllous pycnidial lesions and the hypophyllous aecia (Stevens, *3*).

An investigation of the carotenoid pigments of the pycnidial lesions of crab apple leaves caused by this rust fungus was undertaken in the spring of 1950. Owing to the unusual distribution of rainfall, there was an abundance of leaves that had reached full maturity before they had become infected. The leaves used in this work were harvested June 10, 1950, at the first appearance of a deterioration of the pigments as indicated by the darkening of the pycnia. Approximately 80% of the leaf surface was covered with these lesions. The leaves were placed in pint fruit jars, tightly sealed, and held at −17.4° C until analyzed June 17, 1950.

The pigments were extracted by blending 2 g of leaves in a Waring blendor for 5 min in a mixture of 60 ml ethanol and 150 ml of a mixture of petroleum hydrocarbons[2] consisting principally of hexane (bp 60°–70°) according to the Wall-Kelley (*4*) method. It was obvious from examination that the extraction

[1] Contribution No. 420, Department of Chemistry.
[2] Skellysolve B, Skelly Oil Co., Lyman, Okla.

was incomplete, and consequently the leaf residue, freed from solvent by suction, was again extracted by refluxing 30 min with 40 ml of a 10% solution of potassium hydroxide in methanol. The two extracts were then shaken with the petroleum naphtha to remove the carotenoids. The petroleum naphtha extracts were combined and further shaken with 90% methanol to extract free and esterified xanthophylls. After washing to remove traces of alcohol the petroleum naphtha extract was dried over anhydrous sodium sulphate.

The dried petroleum naphtha extract was chromatographed on a column consisting of equal parts by weight of Hyflo Super Cel and magnesia (No. 2641 Westvaco). Two prominent zones separated; the lower, less strongly adsorbed, was removed by eluting with a 4% solution (by vol) of acetone in the petroleum naphtha. The upper strongly adsorbed zone required an 8% solution of acetone in the petroleum naphtha for elution.

The pigment in the lower zone subsequently was shown by spectrum analysis to be β-carotene. The washings of the upper zone were evaporated to dryness *in vacuo* and taken up in the petroleum naphtha. This solution showed absorption maxima in the petroleum naphtha at 4,600 A, 4,900 A, and 5,340 A, with a minimum at 4,800 A. The absorption maxima and minimum of this pigment, together with its behavior on the adsorbent column, indicated that it was identical with γ-carotene.

The total carotene content of the infected leaves was 83.2 mg/100 g of dry material, of which 28.7 mg, or 34.5%, was the γ-carotene isomer. The uninfected leaves had 32.6 mg of β-carotene/100 g of dry material. No γ-carotene was detected in the normal leaves. Moisture content of the normal leaves was 62.1% when harvested, and infected leaves contained 68.7%.

γ-Carotene is relatively rare in plants, constituting about 0.1% of the total carotene extracted from ordinary sources (*5*). Small amounts have been found in apricots (*6*). MacKinney (*7*) has reported that the marsh dodder (*Cuscuta salina*) is a relatively rich source. A considerable concentration has been found in the fruit of *Pyracantha augustifolia* Schnied (*8*). However, the concentration of γ-carotene in leaves of the crab apple (*Malus ioensis* Britt) infected with the pycnidial lesions of the common rust fungus (*Gymnosporangium juniperi-virginianae* Lk.) is the highest that has come to the attention of the authors.

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Cavitomic Cotton

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An increasing and now large proportion of the spinnable good grades of cotton received by the mills is observed to contain an abundance of cellulose-destroying microorganisms. Deterioration of cotton during warehouse storage has also been noted. The full significance is not known, but the implications are apparent.

Within the limits of our experience, the effects produced by these microorganisms include an effectively shorter staple caused by weakening of the fibers, an

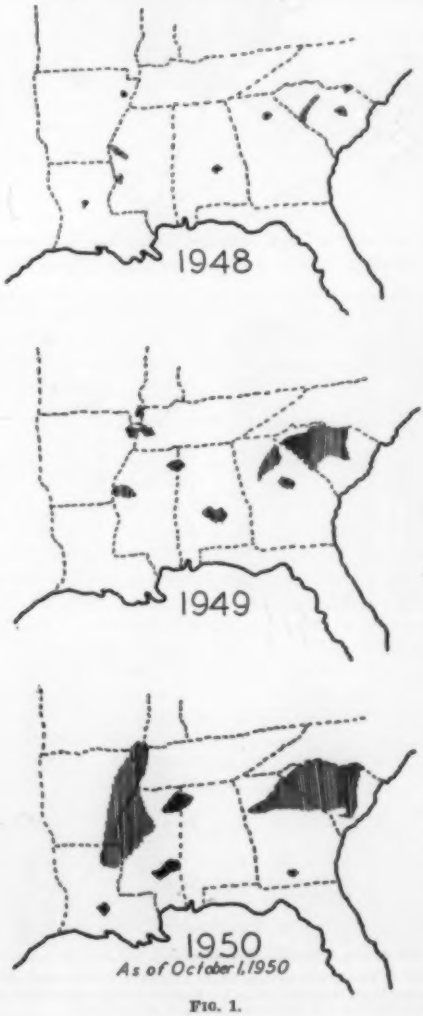


Fig. 1.

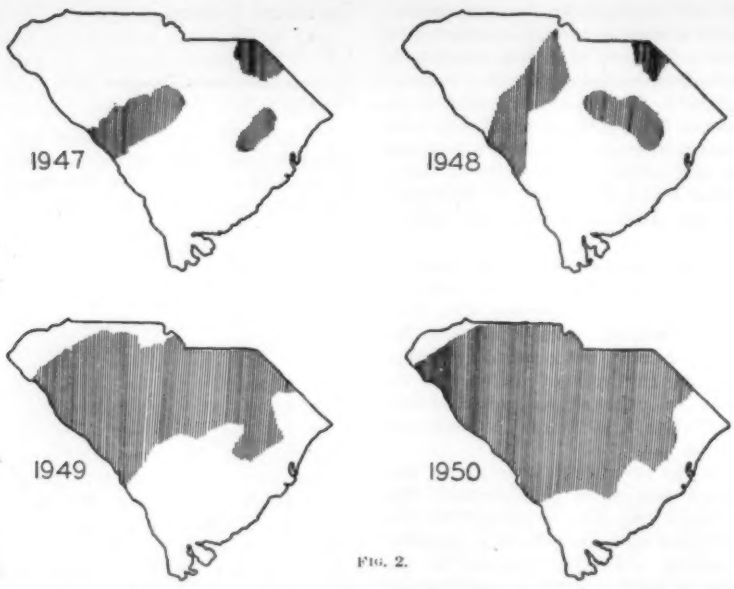


FIG. 2.

increase of "fly" and lint, the formation of dye spots in vat-dyed fabric, and an increased sensitivity to alkali. Severe loss of fabric strength after the usual alkaline kier boil and bleach has in several instances been traceable to fibers apparently damaged by microorganisms prior to the finishing process. The changes in fiber properties brought about by microorganisms are, for convenience, designated here as cavitoma.

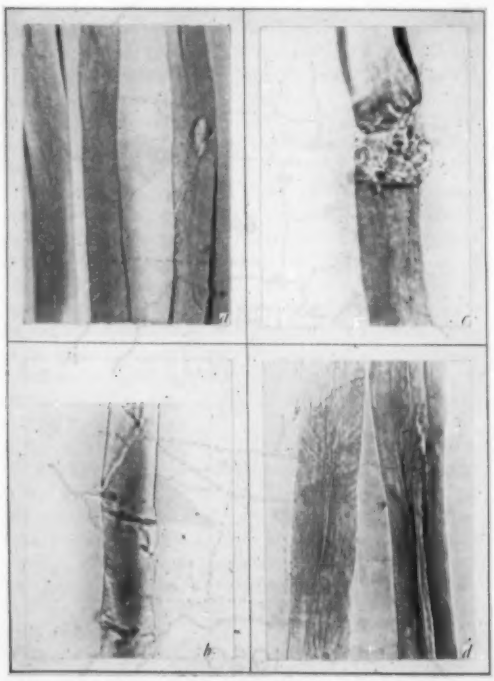


FIG. 3. Cavitomic cotton fibers (×280): *a*, "normal" fibers showing little damage; *b*, large hyphae penetrating fiber wall (note swelling); *c*, ruptured fiber; *d*, striations.

Our records show that areas from which such cottons originate are becoming large. Maps in Fig. 1 show areas from which cottons have been found to possess an abundance of these microorganisms, and Fig. 2 sketches the progress by counties of cavitoma in South Carolina as indicated by our records since 1947. These laboratories have had less occasion to examine cottons from areas west of central Texas, and hence data for these Western areas are relatively meager. Cavitoma was not observed in the Western and California cottons until last season.

This increasingly widespread prevalence of destructive microorganisms in good commercial grades of cotton and the changes in fiber properties are substantially, if not completely, unrecognized in the literature. It is for these reasons that the facts are called to the attention of readers of this journal. The information is being brought to the attention of the U. S. Department of Agriculture, within whose province corrective measures presumably lie.

The mechanism by which cavitoma spreads and is carried over from year to year has not been established. The Department of Agriculture has pointed out the unusually high incidence of tight-lock throughout South Carolina in 1949 (*1*, *2*) and observed no correlation of boll rot with boll weevil infestation. Boll rot is attributed to a contamination of fiber surface from outside the boll. Bacteria and

fungi inside, as well as on the outer surface of the fiber, appear to characterize cavitoma. Cavitoma was observed in 1948 in spite of that season being considered generally excellent for growing cotton.

Cavitoma in its early stages is observed upon microscopic examination of the fibers in caustic of mercerizing strength. One observes fungi, spores, and motile bacteria external to the fiber, hyphae penetrating the fiber wall, and small or pseudo-fungi and bacteria within the lumen of the fiber. As degradation proceeds, the fibers become swollen in regions local to the infection and later throughout the fiber length. Striations of the fiber surface soon appear, revealing a crisscross fibrillar structure. As the degradation continues, the fiber becomes increasingly sensitive to the caustic and in extreme cases is virtually destroyed. The conditions seen in Figs. 3 and 4 are typical.

As deterioration of the fiber proceeds, the presence of cavitoma has also been indicated by the simultaneous existence of a very low reducing sugar content and pH values of 8–9.5 of the readily water-extractable constituents. The tests for sugar and pH have proved most satisfactory for the majority of cottons tested; occasional exceptions are noted. The possibility that fluidity measurements may prove of value in further research has been discussed by Greathouse (*3*). Whether the existence of the observed microorganisms constitutes a primary or secondary phenomenon is not known. It is assumed that the naturally existing and readily soluble carbohydrates and other nutrients provide a satisfactory medium for the initial development of the fungi and bacteria. The sugarlike constituents disappear, and then rise again to about one third their initial amount. In this latter stage the destruction of the fiber becomes strikingly apparent.

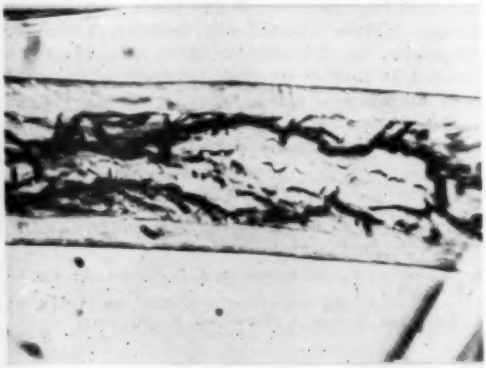
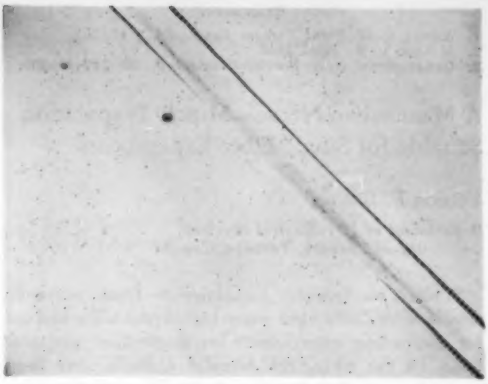


FIG. 4. Cavitomic cotton fibers stained with methyl violet (×790). Fungus or pseudo-fungus in lumen of fiber, and bacteria in lumen of fiber.



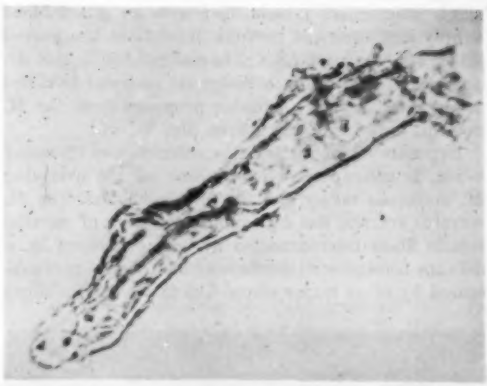


FIG. 5. Sterile and inoculated fibers after incubation (×260).

Steam-sterilized cotton fibers inoculated with a pure strain of one of the organisms from cavitomic cotton produced the result shown in Fig. 5 (*bottom*) after 1 week. Fig. 5 (*top*) shows a sterile fiber after the same incubation.

The observations described above are of concern to the manufacturer and finisher of cotton fabrics, as well as to the ginner, farmer, breeder, and plant pathologist. The scope is far beyond that of any one industrial laboratory. By presentation of this note these laboratories do not wish to circumscribe areas of research; on the contrary, it is hoped that every effort will be made by others to appraise the phenomena.

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A Mammalian Nerve—Muscle Preparation Suitable for Single-Fiber Experiments

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Studies on impulse transmission from nerve to muscle were facilitated when techniques were evolved for conducting experiments on single-fiber preparations. In the main, cold-blooded animals have been used (frog, *1, 2, 3,* and lizard, *4*). The isolation of a single mammalian muscle fiber with an intact blood supply and unbroken nervous connections has proved difficult in the past (*5, 6*). Investigations in this department requiring such biological material have led to the discovery of a suitable preparation in the M. serratus anterior of the guinea pig.

Exposure of the M. serratus anterior, and its motor nerve, is accomplished by division of the overlying M. pectoralis major and the M. rhomboidei. The M. serratus anterior has digitations consisting of parallel muscle fibers interconnected by, and enveloped in, a delicate transparent membrane. The fibers are unobscured by other major connective tissue. At its edges

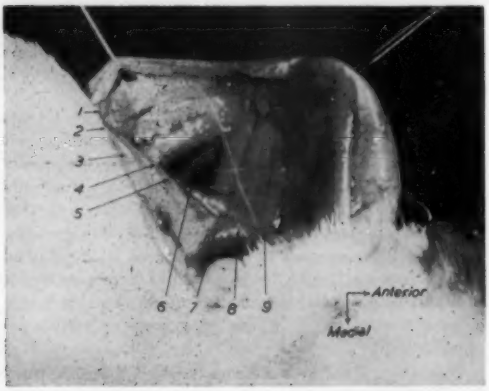

FIG. 1.

each digitation has a depth of only 1 or 2 muscle fibers. Upon laterad deflection of the scapula, the trunk and branches of the N. thoracalis longus, which furnish the motor nerve supply to the M. serratus anterior, are easily seen (Fig. 1). The end plates, or myoneural junction tissue, of the unstained living cells are readily distinguished under the microscope. A photomicrograph of such a preparation (Fig. 2)

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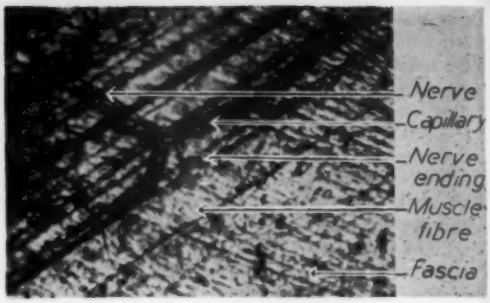

FIG. 2.

shows junction tissue between a muscle fiber and a nerve twig. The vascular supply of the muscle fibers is apparently not disturbed despite the abnormal position of the muscle. If the tissues are adequately irrigated with warm physiological saline or mineral oil the muscle fibers respond to electrical stimulation of the motor nerve for several hours after exposure. The fibers and end plates can be touched and pierced with micropipettes and microelectrodes.

The tendons of the M. serratus anterior are too short to permit easy dissection of the muscle away from its insertions. There is no difficulty, however, in removing the muscle, together with the bones upon which it is inserted, to provide an avascular preparation, which is of advantage at times.

This mammalian preparation may prove useful in various branches of physiology and pharmacology.

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Fluorescence and Photoinactivation of Snake Poisons

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It has been shown by Fonseca Ribeiro and Guimarães (*1*) that potassium chlorophyllinate becomes active for the inactivation of the poison of *Crotalus terrificus terrificus*, either through aging or through light exposition. The mechanism of this phenomenon has not been satisfactorily explained.

In a recent study Ferri (*2*) was able to demonstrate that the photoinactivation of indolacetic acid (phytohormone) by riboflavin discovered by Galston (*3*) should be explained by a mechanism in which riboflavin did not act specifically, since the same inacti-

[1] The authors wish to express their appreciation to Fonseca Ribeiro, Mário G. Ferri, and Annibal A. Pereira.

vation could be brought about by many different substances. Although chemically unrelated, all these compounds had in common the property of fluorescence.

This fact led us to investigate whether the chlorophyll inactivation of snake poison could be attributed to the fluorescent substances that might possibly have been present, even if in very small quantities, in the K-chlorophyllinate solutions. The poison used in the experiments was that obtained from animals of the genus *Bothrops*.

Riboflavin, quinine sulfate (colorless, but with a visible fluorescence), γ-eosin, fluorescein, and K-chlorophyllinate Baker were employed in aqueous solutions of different concentrations as possible photosensitizers. The tests for the toxicity of the preparations were made in pigeons.

The experiments were performed in the following way: 2, 10, or 20 MLD (minimal lethal doses for pigeons) were added to solutions of fluorescent substances. These solutions were then divided in 2 aliquots (containing respectively 1, 5, and 10 MLD), one of which was kept in the dark and the other exposed to direct sunlight for 90 min.

Two ml of each solution was then injected intravenously in pigeons. The action of *Bothrops* poison is detectable within 20 min, but the animals were kept under observation for 4 days.

The results of the experiment are presented in Table 1.

TABLE 1

A. Aqueous solution of riboflavin, 0.01%

Pigeon No.	Wt (g)	Vol injected intravenously (ml)	Observations
1	240	1	Normal behavior
2	260	1	" "

B. 1 ml aqueous solution of riboflavin, 0.01% added of *Bothrops* poison; kept in dark for 90 min

Pigeon No.	Wt (g)	Poison injected intravenously (MLD)	Observations
1	250	1	Normal behavior
2	240	5	Died in 1 min, 30 sec
3	310	10	" " 45 sec

C. 1 ml aqueous solution of riboflavin, 0.01%, added of *Bothrops* poison; exposed to direct sunlight for 90 min

Pigeon No.	Wt (g)	Poison injected intravenously (MLD)	Observations
1	250	1	Normal behavior
2	240	5	" "
3	230	10	" "
4	310	30	" "

TABLE 2

A. Aqueous solution of quinine sulfate, 0.1%

Pigeon No.	Wt (g)	Vol injected intravenously (ml)	Observations
1	240	1	Normal behavior
2	270	1	" "

B. 1 ml aqueous solution of quinine sulfate, 0.1% added of *Bothrops* poison; kept in dark for 90 min

Pigeon No.	Wt (g)	Poison injected intravenously (MLD)	Observations
1	300	1	Died in 8 min, 30 sec
2	310	5	" " 2 " 2 "
3	270	10	" " 1 " 5 "

C. 1 ml aqueous solution of quinine sulfate, 0.1% added of *Bothrops* poison; exposed to direct sunlight for 90 min

Pigeon No.	Wt (g)	Poison injected intravenously (MLD)	Observations
1	280	1	Normal behavior
2	230	5	" "
3	250	10	" "

It may be seen from the data presented that riboflavin alone, as expected, had no effect on the animal behavior. All pigeons injected with the mixture of riboflavin and poison which was kept in the dark died within a few seconds, with only one exception.

All pigeons treated with the light-exposed mixtures remained alive and did not show any poisoning symptoms. It may be concluded from these data that riboflavin is capable of counteracting the toxicity of snake poison in the presence of light but not in the dark. The exception referred to could be due to some accidental exposure to light during the manipulations.

This experiment was repeated with the same results. Analogous experiments in which riboflavin was substituted for one of the other fluorescent compounds mentioned above gave essentially the same results (Table 2).

It seems to us that these data leave no doubt about the fact that the inhibition of the poisoning effect is by no means peculiar to chlorophyll but is a property common to many fluorescent substances. This process thus seems to be analogous in nature to the *in vitro* photoinactivation of indolacetic acid sensitized by fluorescent substances (*2*).

These results led us to investigate whether other properties of the snake poison were altered by light in presence of the fluorescent substances. We shall mention now only the fact that the power of coagulating the blood plasma was almost completely maintained even under circumstances in which the toxicity

was completely removed. Work in this area is under way, and we believe that many important practical applications may arise from the findings.

Other questions being investigated by us are: Is the antigenic property of the poison unaltered by exposure to light in the presence of the fluorescent substance? Are the fluorescent compounds effective in bringing about the inactivation by light of such other toxins as tetanal, diphtherial, staphylococcus, and gangrenous? Should the second question be answered affirmatively, it would then be possible to find a much easier way of preparing vaccines against these toxins and related diseases.

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Nonequivalence of Methyl and Carboxyl Groups in Photometabolism of Acetate by *Rhodospirillum rubrum*[1]

Martin D. Kamen, Samuel J. Ajl, Stanley L. Ranson,[2] and Jack M. Siegel[3]

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It has been shown that the distribution of labeled carbon in carbonate and cell material produced during the dark aerobic dissimilation of C^{14}-labeled acetate by the photosynthetic bacterium *Rhodospirillum rubrum* is the same whether the acetate is labeled initially in the methyl or in the carboxyl group.[4] Hence, it is of interest to report that this equivalence of acetate carbons is not evidenced when labeled acetate is dissimilated photochemically by *R. rubrum*. Typical results are shown in Table 1. To facilitate direct comparison of different experiments, the data have been normalized to the same initial conditions, and amount of acetate metabolized. Experimental uncertainty in any of the values shown is less than 10%.

It will be noted that when methyl-labeled acetate is dissimilated photochemically the distribution in the end products of metabolism differs radically from that observed under identical conditions using carboxyl-labeled acetate. Thus, when 30 μM of acetate are photometabolized anaerobically, the methyl carbon finds its way practically entirely into insoluble cell material, whereas a large fraction of the carboxyl carbon appears as carbonate. Dark aerobic oxidation of the same quantity of methyl-labeled acetate results in the usual accumulation of labeled carbon in carbonate. For comparison of labeled carbonate production in light and dark metabolism it should be noted that observed yields of carbonate per mol acetate disappearing are 0.20 to 0.25 and 0.6 to 0.8 mols, in light and dark, respectively.

The labeled carbon content of the soluble cell material is of the same order of magnitude regardless of the experimental conditions used (Table 1). Extensive analysis of this fraction is not warranted because of the long duration of the dissimilation (~1 hr). However, it may be remarked that ~30% of the activity in this fraction can be identified by paper chromatography as tricarboxylic acid cycle intermediates (e.g., citrate, ketoglutarate, succinate, etc.). No increase in incorporation of labeled acetate carbon in this fraction is noted when carrier amounts of tricarboxylic acid intermediates are added as trapping agents, either in light or dark metabolism. Nor are any changes in distribution of acetate carbon observed when unlabeled substrates that evolve large amounts of CO_2 (malate, succinate, ketoglutarate) are metabolized simultaneously with labeled acetate.

TABLE 1

Distribution of Labeled Carbon After Dissimilation of 30 μM C^{14}-Acetate by Resting Suspensions of *Rhodospirillum rubrum*[*]

Experimental conditions	Light, gas phase, He		Dark, gas phase, air
	Methyl-labeled acetate	Carboxy-labeled acetate	Methyl-labeled acetate
Insoluble cell material (ct/min)	12,500	6,300	4,300
Soluble cell material (ct/min)	975	1,440	1,340
Carbonate (ct/min)	510	6,200	11,450

[*] Initial acetate, 125 μM C^{14}-acetate. All data normalized to initial C^{14} content of 50,000 ct/min. Equal densities of cell suspensions used (22 mg dry wt) in total vol 8 ml phosphate buffer, pH 6.6; 25 μM $NaHCO_3$ also present initially. 90–95% recovery of labeled acetate carbon dissimilated is obtained in cell fractions shown.

These results indicate that anaerobic photodissimilation of acetate by *R. rubrum* very probably does not involve a cyclic mechanism requiring equilibration of the 2 acetate carbons. Such a mechanism, on the other hand, is very likely operative in the dark oxidation of acetate by the same organism. Furthermore, it can be concluded in agreement with previous findings[5] that a major fraction of the acetate undergoes photoassimilation without intermediary formation of carbonate. A detailed account of these researches is in preparation.

[1] The authors gratefully acknowledge the financial support of the Charles F. Kettering Foundation.

[2] Lord Grey Memorial Fellow, University of Durham, England, 1949–50.

[3] U. S. Public Health Service Fellow, 1948–50.

[4] C. B. Van Niel and H. A. Barker, private communication; see also *Photosynthesis in Plants*, J. Franck and W. E. Loomis, Eds. Ames: Iowa State Press, 468 (1949). This observation has been confirmed in our laboratory.

[5] See Footnote 4.

News and Notes

Scientists in the News

Otis O. Benson, Jr., commandant of the Air Force School of Aviation Medicine, was named recipient of the John Jeffries Award for 1950 by the Institute of the Aeronautical Sciences. The award, which includes an honorarium and a certificate, was presented to General Benson for physiological and biophysical studies that have pushed the frontiers of knowledge from 30,000 to 48,000 feet. The John Jeffries Award is made annually to honor the memory of John Jeffries, an American physician who, with the French balloonist Blanchard, made the first aerial voyage across the English Channel in 1785. On a previous voyage Dr. Jeffries made the earliest recorded scientific observation from the air.

The 1950 Hoover Medal was awarded to **Karl T. Compton,** chairman of the Corporation of MIT, for "distinguished public service." The medalist is chosen by a board representing the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Society of Mechanical Engineers and the American Institute of Mining and Metallurgical Engineers. Dr. Compton is the twelfth engineer to receive the medal since it was first awarded to Herbert Hoover in 1930 to commemorate his civic and humanitarian achievements.

C. Julian Douglas, formerly on the faculty of the Department of Biology, Atlanta Division, University of Georgia, has been appointed assistant to the director, University of South Carolina, Extension Division. He was with Florida Chemical Research before going to the University of Georgia.

Lillian Gilbreth, scientific management consultant, has received the Wallace Clark Award of the National Management Council. Dr. Gilbreth was cited for the honor in recognition of 30 years of service in applications of scientific management principles in industry. She is a past director of the NMC.

Albert F. Guiteras, formerly research coordinator and treasurer of Foster D. Snell, Inc., has opened Hudson Laboratories, Inc., in New York City. **Rebecca L. Shapiro,** who was also with Snell, has joined the new organization as chief bacteriologist.

R. N. Haszeldine, Department of Chemistry, Cambridge University, plans to visit the United States from June to September. He will deliver a series of lectures on "Fluorine Chemistry" at Ohio State University some time during that period.

Three civilian physicians have accepted appointments to committees of the Society of U. S. Medical Consultants in World War II, which will assist in providing medical consultation to the Army Medical Service, both in the U. S. and overseas. Heading the committee that will advise on assignment of consultants for Army hospitals in this country is **Joseph M. Hayman, Jr.,** specialist in internal medicine, Cleveland. The overseas committee chairman is **Alfred R. Shands,** orthopedic surgeon, Wilmington, Del. **John B. Flick,** Philadelphia, will fill the general surgery position on the overseas committee. Still to be named are a neuropsychiatrist and a general surgeon for the Zone of Interior committee, and an internist and a neuropsychiatrist for the overseas committee.

Ruth H. Hooker, librarian of the Naval Research Laboratory of the Office of Naval Research, has been appointed to the new position of Coordinator of the Naval Libraries. Mrs. Hooker will also be Navy Department librarian, succeeding **Constance D. Lathrop,** who has retired. **Mildred Benton,** chief, division of field libraries service of the USDA, will succeed Mrs. Hooker as librarian at NRL.

George M. Hunt, director of the Forest Products Laboratory at Madison, Wis., will retire on March 31 after 40 years of continuous service in the Forest Service. His successor will be **J. Alfred Hall,** director of the Pacific Northwest Forest and Range Experiment Station in Portland, Ore. Dr. Hall, in turn, will be succeeded by **Robert W. Cowlin,** present chief of the Division of Forest Economics at the Portland experiment station.

The School of Medicine of the University of Pittsburgh has appointed **I. Arthur Mirsky** as professor of clinical science and chairman of the new Department of Clinical Science, and professor of research psychiatry.

The rank of professor of anatomy emeritus has been conferred on **James W. Papez,** who will retire after 30 years on the Cornell University faculty. He will spend his final term on leave to begin new duties as director of a bureau of research, education, and preventive medicine created recently by the Division of Mental Hygiene, Ohio State Department of Public Welfare. His office will be in Columbus. Dr. Papez, known for his research in the field of neurology, has also been curator of Cornell's Wilder Brain Collection, which includes 150 brains representing extremes of human intelligence.

Maurice Rattray, of Seattle, has been made a deputy administrator of the Defense Fisheries Administration to assist Administrator Albert M. Day and Deputy Administrator Milton C. James in the supervision of the department's program for assuring sufficient fishery commodities to satisfy the country's emergency needs. Mr. Rattray has been president of Anderson and Miskin, Ltd., exporters of canned foods.

Ernest R. Sohns has been made acting chairman, Department of Biology, College of William and Mary.

Until his death last summer, **Donald W. Davis** had been head of this department since 1916.

Hugo Theorell, professor and director of the Medical Nobel Institute, Department of Biochemistry, Stockholm, was this year's lecturer under the Edward K. Dunham Lectureship at Harvard. The lectureship was established in 1923 in memory of Edward K. Dunham, for the promotion of the medical sciences.

Columbia University has announced the appointment of **Charles Hard Townes,** professor of physics, as Ernest Kempton Adams Research Fellow. He will continue research in determining the nuclear properties and molecular structure of various substances. The Adams fellowship was established at the university in 1904 to further research in the physical sciences or in their applications.

Alexander M. White has been selected by the Board of Trustees of The American Museum of Natural History to succeed **F. Trubee Davison** as president, and will take office on October 29. Mr. Davison, who will remain in office until Mr. White assumes the position, had previously announced that he would not be a candidate for reelection after this year. Mr. White, who has been a member of the Museum Board of Trustees since January 1947, will become the sixth president of the institution, which was founded in 1869.

Gian-Carlo Wick has been appointed professor of physics at Carnegie Institute of Technology. He will fill a new professorship supported by the Buhl Foundation of Pittsburgh. Dr. Wick was formerly professor of physics at the universities of Palermo, Padua, and Rome, and at Notre Dame and California. At Carnegie, Dr. Wick will cooperate on the theoretical aspects of the school's physics programs, particularly at the Nuclear Research Center.

Eva Donelson Wilson, professor of foods and nutrition at Pennsylvania State College, has been named head of the department of foods and nutrition in the School of Home Economics. She succeeds **Elisabeth W. W. Dye,** who retired a year ago with emeritus rank. Dr. Wilson is national secretary of Omicron Nu and a member of Phi Upsilon Omicron, home economics honorary societies.

Theodore P. Wright, Cornell University vice president for research, will succeed **Cornelis W. de Kiewiet** as acting president. Dr. de Kiewiet has been granted leave to undertake "a special service abroad" before becoming president of the University of Rochester July 1. Dr. Wright was named vice president for research at the university in 1948, after four years as head of the Civil Aeronautics Administration. He is president of the Cornell Research Foundation and the Cornell Aeronautical Laboratory, Inc., and serves as chairman of the Cornell Defense Coordinating Council to formulate plans for the university's participation in research and educational phases of the national mobilization program.

Colleges and Universities

The College Chemistry National Testing Program, sponsored by the Committee on Examination and Tests of the **ACS Division of Chemical Education,** offers tests for 1951 in general chemistry, qualitative analysis, quantitative analysis, organic chemistry, physical chemistry, and biochemistry. A booklet describing the tests in detail and the tests themselves may be obtained from Educational Testing Service, 20 Nassau St., Princeton, N. J.

The **Institute of General Semantics** will hold a summer Seminar-Workshop Course in General Semantics August 6–September 2 at Bard College. It will be conducted by a group of co-workers who studied with Korzybski. For detailed information and application form, address the institute at Lakeville, Conn.

The former native agricultural school at Fort Cox, Eastern Cape Province, Pretoria, reopened in January as the **Fort Cox Native College of Agriculture.** The new college has a teaching staff of 8 Europeans and 7 natives, and offers courses in animal and field husbandry, horticulture, poultry farming, soil conservation, and handicrafts.

Johns Hopkins, which this year celebrates the 75th anniversary of its founding, plans to give greater breadth to the educational process by eliminating departments of narrow scope, and to speed it up by giving students the opportunity to progress as rapidly as they are able. Sharp distinctions between graduates and undergraduates will no longer exist, and those students capable of doing research and creative work without first completing 8 years of secondary and college education will be allowed to do so. The Johns Hopkins Fund, to which the trustees of the university and the hospital have already subscribed $1,800,000, will be used to carry on the program.

The **University of Illinois** will dedicate its new $3,400,000 East Chemistry Building at a two-day meeting March 30–31. Roger Adams, head of the university's Department of Chemistry, Edward A. Doisy, Vincent du Vigneaud, William L. Faith, Edwin R. Gilliland, Wendell H. Griffith, Norman W. Krase, Robert L. Pigford, William C. Rose, and Thomas R. Wood will be among the speakers. Aspects of chemical engineering and biochemistry will be the principal subjects discussed, for it is to studies in these fields that the new building will be devoted.

Natal University's new medical school for non-Europeans opened in Durban on February 16. It will train qualified non-European medical practitioners for work among their own people in their own areas, where at present there is only one fully qualified doctor for every 22,000 people. The building to house the school will be ready by 1953; in the meantime premedical training will be started at Wentworth.

The University of Oklahoma Biological Station at Lake Texoma will hold its annual summer session

June 9–August 4. Graduate and undergraduate courses in botany and zoology will be given, as well as research courses and problems for the M.S. and Ph.D. degrees. Write to Carl D. Riggs, Director, University of Oklahoma Biological Station, Norman, for information concerning scholarships and graduate and research assistantships open to graduate students.

The board of trustees of the new James Forrestal Research Center at **Princeton** has appointed Daniel C. Sayre, chairman of the Department of Aeronautical Engineering, director, and a five-man administrative committee consisting of Kenneth H. Condit, Hugh Scott Taylor, George A. Brakely, Raymond Jay Woodrow, and Professor Sayre.

St. Louis University's new Summer Institute for the Teaching of Chemistry will be directed by Theodore A. Ashford, for 18 years a member of the faculty of the University of Chicago. Information about the courses to be offered may be obtained from Dr. Ashford.

Stanford University will build two new electronics laboratories, one for applied research and one for student electrical engineering activities, which will be under the direction of Frederick E. Terman, of the School of Engineering. The electrical engineering laboratory was made possible through a gift from Hewlett-Packard Company, of Palo Alto. Stanford has just received an ONR contract for research in applied electronics, which will supplement existing basic research contracts already held by the university with ONR, the Air Force, Signal Corps, and the National Bureau of Standards.

Trinity College, in cooperation with the United Aircraft Computing Laboratory, is offering a new course that combines lectures on numerical mathematical analysis and machine methods with the use of IBM punch-card computing machinery. Stuart L. Crossman and Walter Ramshaw are in charge of the work.

Tulane University has established a 2,000-acre swamp area as a research refuge for the study of fish, amphibian, and reptile populations. The refuge, named the Sarpy Wildlife Research Refuge, was established through the generosity of Leon Sarpy, New Orleans attorney.

The University of Chicago will hold two workshop seminars in the Rorschach test, June 4–8, and June 11–15, to be conducted by S. J. Beck. Students at, or ready for, the interne level may take the first course, but admission to the second workshop is limited to psychologists and psychiatrists in clinical positions or practice. For further information, write to Dr. James G. Miller, of the Department of Psychology.

Under the sponsorship of the **University of Michigan Center for Japanese Studies,** a faculty member, Mischa Titiev, and three students, Forest Pitts, David Plummer, and David Wheatley, have gone to the center's field station at Okayama, to carry on research into the general problem of the effect of Western civilization on Japan's folk culture.

Sponsored by the School of Medicine and the Extension Division of the **University of North Carolina,** postgraduate medical courses for practicing physicians will be given at North Wilkesboro–Elkin (March 30–April 24) and at Shelby (March 21–April 25), with guest speakers from various areas.

The **University of Wisconsin** has appointed Milton Davis, Jr., as associate professor of anesthesia in the medical school. Dr. Davis has been in private practice in Danville, Ky. Wilber J. Tyler has been appointed associate professor to head the dairy cattle breeding project at Emmons Blaine, Jr., experimental farm near Lake Mills. He comes from the University of West Virginia.

Eight of the nation's outstanding chemical scientists are participating in the "Frontiers in Chemistry" lecture series at **Wayne University,** under the sponsorship of the International Society of the Friends of the Kresge-Hooker Library and Wayne's department of chemistry. The lecturers include Winston M. Manning, Argonne National Laboratory; G. E. Boyd, Oak Ridge National Laboratory; John E. Willard, University of Wisconsin; Linus Pauling, Caltech; Charles D. Coryell, MIT; Joseph J. Katz, Argonne National Laboratory; A. V. Grosse, Research Institute of Temple University; and Leonard F. Yntema, Fansteel Metallurgical Corporation.

Grants

Approximately 70 **Fulbright** awards for university lecturing and advanced research in Australia, Burma, India, New Zealand, Pakistan, the Philippines, and Thailand will be made for 1952–53. Application forms (returnable not later than *April 15*) and additional information may be obtained from Executive Secretary, Committee on International Exchange of Persons, 2101 Constitution Ave., Washington 25, D. C. Graduate students desiring to enroll for courses abroad should apply to their local Fulbright committees or directly to the Institute of International Education in New York City.

The **Lumber Dealer's Research Council** will underwrite the study by the Small Homes Council of the University of Illinois of interior partitions that will include provisions for storage. Under a grant of $4,650, the council will carry on a year's investigation. It will then recommend procedures expected to result in increased storage efficiency, as well as lower construction costs.

Twenty medical scientists in as many U. S. and Canadian institutions, comprise the fourth group of "Scholars in Medical Science" appointed by the **John and Mary R. Markle Foundation.** The grant has been increased by $1,000, making the five-year total $30,000, instead of $25,000. Beginning July 1 this increase will apply also to the 46 grants made during the first

three years of the program. All grants are made direct to the medical schools at the rate of $6,000 annually.

Two grants from the **National Cancer Institute** have been made to the Chicago Medical School for training and research under the direction of Philippe Shubik, coordinator of the Cancer Teaching Program. One is a renewal of $25,000 for cancer teaching, and the other is a grant of $10,000 allocated to research in the mechanism of the chemical production of cancer.

The Russian Institute, School of International Affairs, of Columbia University, has received $420,000 from the **Rockefeller Foundation** to be used over a five-year period. The two-year course given by the institute comprises such studies as international relations, Russian history, economics, law, and Russian culture and civilization, including contemporary culture. Familiarity with the Russian language is prerequisite.

A grant of nearly 400,000 kronor ($80,000) from the **Knut and Alice Wallenberg Foundation** will aid cancer research in the laboratory attached to the Department for Cytology of the Nobel Institute for Medicine in Stockholm. Major portion of the grant will be used to organize a special cancer research group under the direction of Torbjörn Caspersson. His colleagues will be Gunnar Moberger and K. G. Thorsson.

Manpower

Plans for a survey to determine the potential for research in physical and engineering sciences in all American colleges and universities have been announced by Athelstan F. Spilhaus, of the University of Minnesota, chairman of a subcommittee of the **Engineering College Research Council.** The committee's report, due about April 1, will indicate the fields of research of particular interest to all institutions surveyed, their facilities, and the availability of personnel. Copies will be supplied to the Research and Development Board and, through it, to all military agencies concerned with contracting for the research services of colleges and universities. The findings will also be reported to the Atomic Energy Commission, National Science Foundation, and other Federal and industrial groups.

The survey will cover a broad list of scientific fields, including aeronautical engineering, astronomy, ceramics, chemical engineering, chemistry, civil and sanitary engineering, electrical engineering, electronics, food technology, geology, industrial engineering, marine engineering, mathematics, mechanics, metallurgical engineering, meteorology, mining engineering, oceanography, petroleum and fuels engineering, physics, and psychology and human resources. The project is under the direction of the ECRC's Committee on Relations with Military Research Agencies, of which Dean Spilhaus is chairman. Other members are Allan P. Colburn, University of Delaware; W. L. Everitt, University of Illinois; F. B. Farquharson, University of Washington; C. W. Good, University of Michigan; Paul E. Klopsteg, Northwestern University; James S. Owens, Ohio State University; J. R. Van Pelt, Battelle Memorial Institute; and Eric A. Walker, Pennsylvania State College.

Lehigh University has announced the establishment of a year-round school program to enable students to speed up their college education. Martin D. Whitaker, president, also announced plans to permit the entrance of a section of the 1951 freshmen class this June. The decision to stress summer school work is the university's answer to a heavy demand from secondary school seniors to begin and continue their college education immediately upon graduation. The "Continuous Program of Studies" is designed to help meet the nation's military and manpower needs in the international crisis. Not compulsory, the new program at Lehigh will enable students to attend summer sessions of 12 weeks and to complete the requirements for a bachelor's degree in 3 years.

Meetings and Elections

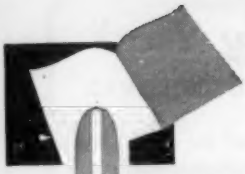
Justin M. Andrews, of Atlanta, deputy officer in charge of the Communicable Disease Center, USPHS, has been elected president of the **CDC Branch of RESA,** succeeding R. A. Vonderlehr, medical director in charge of the center and first president of the CDC Branch. Other officers of the society include George Bradley, vice president; M. M. Brooke, secretary-treasurer; and R. F. Reider and James H. Steele, members of the executive committee.

The **Animal Care Panel,** at its first national meeting at the University of Chicago last November, elected the following officers: N. R. Brewer, chairman; C. A. Slanetz, vice chairman; and Bennett J. Cohen, secretary-treasurer. The meeting was attended by more than 75 representatives of biological institutions in the U. S., Canada, Australia, and the Philippines.

The **Division of High Polymer Physics** of the American Physical Society has elected the following officers for 1951: chairman, J. Burton Nichols; vice chairman, Maurice L. Huggins; secretary-treasurer, W. James Lyons.

An **International Society of Tropical Foresters** was formed at a meeting last December in Washington, D. C. Membership in the society is open to foresters of all nationalities working in all types of tropical forest products. No dues are required, and those interested in joining should write to Tom Gill, 1214 16th St., N. W., Washington 6, D. C.

The **Wyoming Geological Association** will hold its annual Field Conference July 31–August 3, inclusive. Areas that will be included in the daily field trips are Separation Flats, the Ferris and Seminoe Mountains, and the Sweetwater and Rawlins uplifts. Headquarters will be in Rawlins, Wyo. Those who wish to participate can obtain additional details from Tom Bailey, P. O. Box 2249, Casper, Wyo.



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Meetings & Conferences

Mar. 18–22. Association of American Geographers. Palmer House, Chicago.

Mar. 19–20. Central Plant Board. Commodore Perry Hotel, Toledo.

Mar. 19–20. American Association of Physical Anthropologists (Annual). Ann Arbor, Mich.

Mar. 19–20. Histochemical Society. Detroit, Mich.

Mar. 19–23. Seventh Western Metal Exposition. Auditorium and Exposition Hall, Oakland, Cal.

Mar. 20–21. Society of Experimental Psychologists. University of Virginia, Charlottesville.

Mar. 21–22. American Association of Economic Entomologists (North Central States Branch). Commodore Perry Hotel, Toledo.

Mar. 21–22. Symposium on Nature and Significance of the Antibody Response. New York Academy of Medicine.

Mar. 21–23. American Association of Anatomists. Detroit.

Mar. 22–24. Michigan Academy of Science, Arts and Letters. Michigan State College, East Lansing.

Mar. 23–24. Southern Society for Philosophy and Psychology. Hotel Roanoke, Roanoke, Va.

Mar. 23–24. Fourth Regional Conference on Premedical Education. Alpha Epsilon Delta in cooperation with University of Alabama, Tuscaloosa.

Mar. 26–29. American College Personnel Association. Stevens Hotel, Chicago.

Mar. 29–31. Congress of the Ophthalmological Society of the United Kingdom (Annual). London.

Mar. 29–31. Minnesota Section, American Chemical Society, Symposium on Chemistry and Functions of Proteins. Natural History Museum, University of Minnesota.

Mar. 30–31. Eastern Psychological Association. St. George Hotel, Brooklyn.

Mar. 30–Apr. 1. Conference on The Use of the Film in Training for Industry. Hotel Majestic, St. Annes-on-Sea, Eng.

Apr. 2–5. American Society of Mechanical Engineers (Spring). Atlanta.

Apr. 2–6. Conference on Radioisotopes in Industry. Case Institute of Technology, Cleveland.

Apr. 4–6. Midwest Power Conference (Annual). Sherman Hotel, Chicago.

Apr. 6–7. Texas Academy of Science (South Texas Regional). Corpus Christi.

Apr. 8–11. Electrochemical Society. Wardman Park Hotel, Washington, D. C.

Apr. 9–13. American College of Physicians (Annual). St. Louis.

Apr. 11–13. Faraday Society Symposium on Hydrocarbons. Oxford, Eng.

Apr. 11–13. American Surgical Association. Washington, D. C.

Apr. 16–18. American Society of Lubrication Engineers (Annual). Bellevue-Stratford Hotel, Philadelphia.

Apr. 16–18. Union Radio Scientifique Internationale. National Bureau of Standards, Washington, D. C.

Apr. 18–20. National Petroleum Association. Hotel Cleveland, Cleveland.

Apr. 20–21. British Association of Physical Medicine. London.

Apr. 20–21. College of American Pathologists (South Central Regional). The Shamrock, Houston, Tex.

Publications Received

Construction and Operation of Ground Equipment for Applying Concentrated Sprays. S. F. Potts, *et al.* Connecticut Agricultural Experiment Station, New Haven. Oct. 1950.

Russell Sage Foundation. Annual Report 1949–50. Russell Sage Foundation, New York. 1951.

Some Biological Effects of Ditching Tidewater Marshes. Warren S. Bourn and Clarence Cottam. Research Report 19; ***Fishing Gear Preservatives for Philippine Waters.*** John A. Clague and Bienvenido Datingaling. Research Report 22; ***Liver Oil Properties of Philippine Sharks and Rays.*** William S. Hamm. Research Report 23; ***Bacteriological Studies of Philippine Fishery Products.*** John A. Clague and Crisanto Almario. Research Report 27. Fish and Wildlife Service, GPO, Washington. 1950.

Research in Industry. Bengal Immunity Research Institute, Calcutta.

Ninth Semiannual Report of the Atomic Energy Commission. United States Atomic Energy Commission, GPO, Washington. Jan. 1951.

The Temporal Region of the Permian Reptile Diadectes. Everett Claire Olson. 20¢. ***A Middle Devonian Octactinellid Sponge from New York.*** Eugene S. Richardson, Jr. 25¢. ***Bats from New Caledonia, the Solomon Islands, and New Hebrides.*** Colin Campbell Sanborn and A. J. Nicholson. 40¢. ***A Study of the Spotted Tinamous: Genus Nothura.*** Boardman Conover. 25¢. ***A Study of the Elegant Tinamous: Genus Eudromia.*** Boardman Conover. 15¢. Chicago Natural History Museum, Roosevelt Road and Lake Shore Drive, Chicago 5.

Turkey Foot Ridge Site: A Mogollon Village, Pine Lawn Valley, Western New Mexico. Paul S. Martin and John B. Rinaldo. Fieldiana: Anthropology, Vol. 38, No. 2. Chicago Natural History Museum, Roosevelt Road and Lake Shore Drive, Chicago 5. $2.75.

The Teaching of Science in Public High Schools. Philip G. Johnson. Bull. 1950, No. 9. U. S. GPO, Washington 25, D. C. 20¢.

The Atomic-Molecular Theory. Leonard K. Nash. Harvard Case Histories in Experimental Science. Harvard Univ. Press, Cambridge, Mass. $1.35.

The Type Specimens of Certain Oriental Eucosmidae and Carposinidae. A. Diakonoff. Vol. I, No. 4. British Museum (Natural History), Cromwell Road, London, S. W. 7.

The Next Half Century in Medicine: A Symposium. Sterling-Winthrop Research Institute, Rensselaer, N. Y.

Modernization Programs in Relation to Human Resources and Population Problems. Milbank Memorial Fund, New York. 50¢.

Thomas Bartholin. Axel Garboe. Library Research Monographs, University Library, Copenhagen. (Einar Munksgaard).

Bibliography on Domestic and Industrial Applications of Solar Heating. No. 7. Engineering Societies Library, 29 W. 39th St., New York 18. $2.00.

A Progress Report on Cortisone and ACTH. Arthritis and Rheumatism Foundation, 535 Fifth Ave., New York 17.

An Index of Tumor Chemotherapy. Helen M. Dyer. Cancer Reports Section, National Cancer Institute, Bethesda 14, Md.

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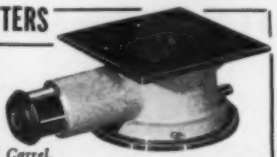

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